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Disaster and mass casualty events in the pediatric population

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Recent disasters involving pediatric victims have highlighted the need for pediatric hospital disaster preparedness. Although children represent 25% of the U.S. population, there are significant gaps in pediatric disaster preparedness across the country. Disaster planners and others tend to overlook pediatric needs, and therefore plans are often inadequate. To establish an effective hospital and community-based pediatric disaster management system, administrative and hospital leadership are key. Disaster planners and hospital leadership should establish and improve their management of pediatric victims in the event of a disaster through staff training, family reunification planning, and use of available pediatric disaster management tools.

Recent disasters, such as the devastating earthquakes in China and Haiti, involving pediatric victims have highlighted the need for pediatric disaster preparedness. Currently, the approach to pediatric disaster preparedness in the United States is in evolution.[1] The purpose of this article is threefold: (1) to discuss the importance of pediatric disaster planning; (2) to provide approaches to establishing and managing teams within an institution; and (3) to propose recommendations in integrating pediatrics into the emergency disaster plan.

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Disaster planning for the pediatric population

Importance of disaster planning for the pediatric population

Disaster planning that thoroughly incorporates the specific vulnerabilities of the pediatric population serves to increase a health care facility's success in treating children involved in a mass casualty incident.[2] However, disaster planners tend to overlook pediatric needs. Moreover, there exists an expectation during crises that children can and should receive the same care as adults.[3] Emergency planning for children is a high priority because recent evaluations of existing systems suggest that pediatric resources and specialties may become overloaded.[4] Children will arrive at adult hospitals; therefore, adult practitioners at medical facilities should be prepared to care for children during emer-

gencies and disasters, and, as a consequence, hospitals must be prepared for a surge in pediatric victims.[3] However, disaster plans often fail to include pediatric considerations.[5,6] Though most prehospital emergency medical services agencies report having a written plan for response to a mass casualty event, only 13% report an analogous component for a pediatric mass casualty event.[7] In addition, recent events have reiterated the need for well-coordinated planning for mass casualty events.[8] There are substantial deficiencies in the preparedness plans of hospitals in the United States.[9] Although children exhibit significantly higher mortality rates in disasters when compared with the adult population,[2] hospital capacity for children is smaller and concentrated at far fewer facilities than that for adults.[10] For example, national policy for emergency preparedness calls for hospitals to accommodate surges of 500 new pediatric patients per million pediatric population in a disaster, but there are insufficient vacant hospital beds available to serve 500 children per million pediatric population.[11] Because of their distinctive vulnerabilities, which are discussed in more detail below, it is crucial that pediatric needs are built into every stage of the disaster planning process.[2,10,12]

Unique characteristics of the pediatric population and disaster planning

Distinctive physiological, developmental, and psychological attributes of children make them one of the most challenging populations to treat during mass casualty incidents. Because of their unique biological, social, and ethical factors, it is crucial that pediatric needs are incorporated into every facet of disaster planning.[3] Anatomically, children's solid organs are proportionately larger, closer together, and not as well protected as adult organs. Young children have respiratory and heart rates that are faster than adolescents and adults, thereby, increasing their susceptibility to airborne chemical and biological agents that will quickly spread throughout a young child's circulatory system. Children also metabolize drugs differently than adults; therefore, they require varying dosages of medications and antidotes, whereas, in most cases, a wider array of adults may be treated with a single dose. Clinicians may need smaller equipment for medication administration. Children also have a different respiratory physiology that varies by age. Young children will potentially absorb more hazardous substance before it is cleared or diffuses from the respiratory tissues. Many chemical agents, including certain gases such as sarin and chlorine, have a high vapor density and are heavier than air, which means that they "settle" close to the ground, in the airspace used by children.[13] Some biological and chemical agents are absorbed through the skin. Because children have a greater surface area relative to body mass and more permeable skin than adults, they receive proportionally higher doses of agents that either contact or seep into the skin. Fluid and electrolyte balance may be difficult to maintain in young children; they easily become dehydrated and suffer circulatory collapse because they possess minimal fluid reserve. Therefore, young children are at greater risk for severe dehydration than adults when exposed to agents that cause diarrhea and/or vomiting.[14]

Developmentally, young children are particularly vulnerable because of physical and mental limitations based on developmental milestones. For instance, infants do not have the motor skills to escape from the site of a biological or chemical incident. Even if toddlers are able to walk, they may not have the cognitive ability to understand the presence of risk based on a terrorist event and therefore may not escape or be able to decide in which direction to flee. In the worst case scenario, a young child may actually go toward the event out of curiosity to see the gas, colored agent, or other effects.[13,15]

Because young children depend on adults for sustenance, security, and socialization, they are among the most susceptible community members when catastrophes occur.[16] Developmentally, infants, toddlers, and young children lack the self-preservation and cognitive skills that enable them to know how to react. Furthermore, the coping skills of children are less developed than those of adults. A child's mental health suffers not only from direct exposure to traumatic events but indirect exposure as well. After a disaster event, children are at risk of developing anxiety attacks, especially when separated from caregivers. Children may have a greater risk of developing posttraumatic stress disorder and other enduring behavioral disturbances.[17] Based on the anatomical and psychological variations that children present in a disaster response, clinicians must plan on using smaller devices and age-appropriate treatment tactics.[18]

Although pediatric-sized emergency equipment is needed to properly treat ill or injured children, some of the chief challenges to planners and hospital administrators are the cost and logistics associated with maintaining an expanded inventory. We have developed two approaches to making better estimates for the potential surge in pediatric disaster victims. Mills and colleagues postulate that geographic information system analysis of a hospital's catchment area is a reasonable starting point for estimating the pediatric surge.[19] Another approach is to run pediatric surge simulations based on the most likely hazard in the region. Neches and colleagues generated a pediatric supply and logistic software program [see discussion of Pediatric Emergency Decision Support System (PEDSS) below] that estimates pediatric supply needs based on end-user surge census.[20] Both of these models need further refinement and validation, but they are the first steps in refining a planner's approach to a pediatric surge during a crisis. Finally, the variation in number and types of equipment is not only a budgetary concern but also an education and training issue.[21] This section summarized the unique features of children that may contribute to a rapid destabilization in this population and the considerations that a planner must make to prepare for these variations. In the following section, we

will highlight some process issues that need careful consideration when providing care for children in the aftermath of a disaster.

Disasters, reunification, and the pediatric population

For practical and legal reasons, children require supervision after a disaster event. Therefore, hospitals need a plan for supervision and family reunification in the likely event that families become separated after a disaster. Recent mass casualty incidents, such as the Haitian earthquake, Hurricane Katrina, and the Sichuan earthquake in China, highlight the need for strategies that minimize parent–child separation and improve methods for reuniting separated children with their families. When children are the majority of casualties, the issues become even more difficult, because some children, who are preverbal, cannot speak their names or their parents' names. Thus, the injured child poses two problems for the hospital or response agency: (1) providing appropriate medical care and (2) coordinating the family reunification process. A recent report revealed that hospitals lack written plans on reunification and repatriation of pediatric patients and family members.[22]

In 2008, the Pediatric Disaster Resource and Training Center (PDRTC) at Childrens Hospital Los Angeles held a two-part Reunification Conference that brought experts together to deliberate and decide on family reunification recommendations.[22] Expert panels discussed topics such as: (1) patient movement/transportation, (2) technology/tracking, (3) clinical issues, (4) nonmedical issues, (5) communication/regulatory issues, and (6) pediatric psychological support for the aftermath. Participants agreed that additional work is necessary to develop tracking systems that are interoperable and transportation and care of unaccompanied minors. In addition, the development of tracking technologies will require a discussion focused on an ethical framework for privacy concerns that these maneuvers will challenge.

Institutional staffing during a disaster

During and after a disaster, health care facilities will have to adapt their staffing because additional reinforcements may not be readily available to care for the wounded and their families. Therefore, determining pediatric hospital-based health care workers' perceptions, capabilities, and training before a disaster is crucial in understanding and preparing for human resource gaps in pediatric disaster responses. Though an organization can never be certain about staff availability until the actual disaster event, preparation and planning are vital in ensuring seamless facility operation. Previous studies have projected a 17% overall reduction in workforce for a mass casualty event.[23] Several studies have demonstrated that family and child care play a significant role in health care workers' willingness to respond.[24-28] Organizations can take certain actions, such as programs to support family care, to increase staff availability in the event of a disaster. One study estimated that 38% of staff may be absent from work due to the impact of child care and school closure in the event of an influenza pandemic.[26] Qureshi et al. identified certain barriers, including dependent care and concerns for personal and family safety.[27] There have been several reports documenting that provisions made by hospitals for their families have led to successful treatment[29] and evacuation[30] of patients during disasters.

In addition, pediatric disaster preparedness training may also increase staff's availability and willingness to report to work in the event of a disaster. Chokshi et al. found that 77% of surveyed surgeons felt "definitely" responsible for assisting during a disaster, but only 24% of respondents felt "definitely" prepared to respond to a disaster. Most felt they needed additional training, with 74% stating that they definitely or probably needed to do more training.[31] A study of pediatricians found that 76% percent of all respondents indicated their desire for additional training.[32] Overall, health care workers' perceptions are clearly relevant[33] and indicate that they require additional training to feel fully prepared to respond. Efforts to provide employees with instructions for a general early response to medical disasters might foster a greater sense of readiness.[34]

Tools for pediatric disaster preparedness

The PDRTC at Childrens Hospital Los Angeles (CHLA) was expanded in 2007 to coordinate pediatric patient surge capacity among hospitals throughout Los Angeles County and to enhance the educational programs. The Center's two primary goals are to promote coordinated, effective medical care delivery to pediatric disaster victims and to inform and assist other hospitals in treating children who arrive at their door in response to a large-scale incident. To accomplish these goals, the PDRTC developed several tools that will assist, instruct, and prepare hospital emergency planners and health care workers to effectively respond to children in the event of a disaster. Leaders and emergency planners at hospitals and other health care facilities around the country can easily adapt these programs to their local environment. Planners can acquire information online to access all the PDRTC research findings and recommendations (http://www.chladisastercenter.org). The first critical step in adopting many of the recommendations is to identify the important hazards in the local and regional environment and then customize your plan.

As mentioned above, the Informatics Core of the PDRTC developed PEDSS, in collaboration with the engineers at the Information Sciences Institute at the University of Southern California.[20] The software application is free and Web-based (http://pedss.isi.edu/pedss). The application helps hospitals determine the pediatric medical and pharmaceutical supplies needed in the event of an earthquake, the most

common type of disaster event to occur in Los Angeles County. The application collects contextual information, such as demographics, and capabilities, such as surge capacity per injury type, and then determines the required medical supplies based on the estimated number of children and available hospital resources. In developing the parameters for this software, we analyzed epidemiologic,[35,36] census,[37] and CHLA Trauma Department data to develop algorithms for predicting pediatric surge and injuries. We reviewed and summarized the literature[5,8,11,38] and guidance documents[3,6,7,12] on the needs of children involved in all-hazard disasters to identify the best practices for pediatric disaster response. The pediatric evidence-based guidelines incorporated in this version of the software were reviewed, developed, and endorsed by subject matter experts. The application is currently being expanded to include other disaster events, such as fires, floods, and hurricanes as well as a family reunification module.[20]

Another PDRTC tool, produced in collaboration with the University of Southern California School of Cinematic Arts, is a serious video game called SurgeWorld. The game, which is available free online (http://www.chladisastercenter.org), simulates the fast pace of a hospital setting during a real-life disaster and trains providers and disaster preparedness personnel to triage and manage the surge of pediatric disaster victims. The triage algorithm embedded in the game is based on the JumpSTART© triage algorithm. CHLA's Trauma Program, Emergency Department, and disaster preparedness subject matter experts developed the individual clinical data and hospital operation framework. Additional investigation is needed to validate the educational value of this novel approach to triage training.

Hospital-based pediatric disaster management

The uniqueness of children's needs in disasters and large-scale emergencies makes it crucial for leaders in health care to work together to develop systematic approaches to pediatric disaster planning and management. In fact, leadership rather than formal management has been perceived as a primary contributor to an organization's emergency preparedness.[39] In collaboration with regional or state-level associations that provide an opportunity for planning and preparedness that exceed the capability of the individual hospital or hospital system, hospital leaders work with other stakeholders in conducting regional disaster planning. Stakeholders include hospital associations, hospitals, schools, municipal agencies, citizen groups, and others. Comparative case studies find that there is variation in partnerships for preparedness but suggest that strong leadership and trust are critical to planning and sustainability through more efficient use of resources and better-coordinated responses.[39]

Essential to the development of a successful preparedness program is executive administrative support. Administration, including physicians, participates in program development and ensures adequate support for training. There must be an observable commitment to employee disaster preparedness to ensure they get the training and education they need.

Training and education

Hospital-based disaster training is driven largely by regulatory mandates and not performance metrics, and therefore the training quality is quite variable.[40] Most accredited hospitals test their emergency preparedness plans based on the Joint Commission's requirements that health care facilities conduct disaster drills twice a year.[41] The type of drills range from tabletop exercises to simulations to full-scale disaster scenarios.[42] The objectives of disaster drills are: (1) to evaluate the ability of health care workers to perform emergency plans, (2) to train staff on roles and responsibilities during a disaster, (3) to assess disaster-related knowledge and skills, and (4) to identify gaps and weaknesses in disaster-related knowledge and skills.[42-44] Recent data suggest that most hospitals do not drill with pediatric disaster victims.[43-46] Facilities often overlook simulating disaster scenarios with children, thus missing a crucial opportunity to assess their own shortcomings. As a consequence, a disaster with a large proportion of children will lead to poor coordination, subpar resource management, and, unfortunately, adverse health outcomes. The recent disaster in Haiti highlighted the subpar response that can occur when the at-risk population contains large numbers of children. In Haiti, approximately 40% of the population is children, yet many of the responders did not have sufficient pediatric-specific resources (H. Ford, personal communication).

The purpose of disaster exercises is for hospital planners to assess the ability to execute contingency plans, increase knowledge about disaster response procedures, train staff on disaster roles and responsibilities, test acquired knowledge and skills, and identify weaknesses and resource gaps—thereby improving emergency management systems. However, hospitals rarely address pediatric needs during drills and simulations, despite recommendations to include children. Thus, the medical and emergency preparedness community lacks knowledge of pediatric issues and challenges potentially encountered in exercises specific to the childhood population and the ability to identify needs and areas of improvement for pediatric care in disaster situations.

Education and training on mitigation, preparedness, response, and recovery are needed at all facilities for all personnel. This includes annual statewide exercise, regional drills, and exercises. CHLA recently instituted a novel pediatric-focused disaster course for all new and existing clinical and nonclinical staff (http://www.chladisastercenter.org). Nonclinical staff are required to complete the course because, as mentioned above, clinical staffing may be limited in the event of a real disaster.

Recommendations

Disaster plans that include response features that take into account the specific vulnerabilities of the pediatric population should increase a hospital's opportunity to successfully treat children involved in a disaster. To that end, we provide the following recommendations based on the work of the PDRTC.[39]

Plan:

- Incorporate pediatric patients into all planning efforts;
- Develop plans to ensure safety and supervision of children until united with family;
- Define hospital command center procedures and roles;
- Develop internal communication plans; and
- Arrange for increased resources.

Practice:

- Drill often;
- Include sufficient proportion of pediatric patients in drills (15%-20% of victims);
- Consider drills specific to pediatric victims to test ability to handle pediatric patients;
- Modify plans for training;
- Staff based on drill results.

Prepare:

- Stock size-appropriate supplies and equipment;
- Identify staff with expertise in pediatrics;
- Train clinical staff in pediatric triage, medication doses, Pediatric Advanced Life Support, and Emergency Nursing Pediatric Course;
- Develop means to identify victims and family members; and
- Discuss legal dilemmas with general counsel and develop internal policies, procedures, forms, and databases.

Partner:

- Consider collaborative planning and training with other area hospitals and agencies and develop a means to communicate with other hospitals in the event of a disaster; and
- Establish a regionalized system of care to build surge capacity and better facilitate family reunification.[39]

Family reunification[22]:

- Create predetermined processes for identifying children's guardians should they be separated during a disaster;
- Identify designated shelters that can safely accommodate children with or without guardians;
- Designate alternative care sites that can accommodate and provide medical care to children who are with or without guardians;
- Establish release protocols and resource lists to ensure appropriate release of children;
- Prepare and drill for the welfare, safety, and security of separated children; and
- Develop a child identification national database.

Conclusions

Recent disasters have highlighted the lack of hospital pediatric disaster preparedness. To establish an effective hospital and community-based pediatric disaster management system, hospital disaster planners and hospital leadership should establish and improve their management of pediatric victims in the event of a disaster through staff training, family reunification planning, and use of available pediatric disaster management tools.

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